Wisconsin Highway Research Program Proposal

Evaluation of Flow Number F_n as a Discriminating HMA Mixture Property

Prepared by

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Projects 9-25 and 9-31. This model can be used to identify the variations in composition that should be included in the laboratory evaluation proposed for this project.

Benefits

The proposed research will be extremely valuable to the Wisconsin DOT. It will build on the findings of WHRP Project 0092-04-07 and extend the anticipated findings from WHRP Project 0092-08-06 to mixtures that vary from the accepted job mix formula. The relationships between the flow number and mixture composition developed in this project will provide guidance to mix designers for meeting specified levels of rutting resistance. The findings will also provide relationships that can be used to verify current acceptance criteria or improve them if they are found to be inappropriate. Implementation of the finding from this study will result improved HMA mixture design and acceptance criteria that minimize the risk associated with premature failure, resulting cost savings to the public.

Implementation

The findings from this research can be implemented immediately. The project will produce recommended flow number test methods and criteria for use in the design of HMA mixtures in Wisconsin. Criteria for various traffic levels and positions in the pavement structure will be recommended. The project will also produce relationships between mixture composition and the flow number that can be used by engineers and technicians involved in the design and acceptance of HMA. A tutorial that demonstrates the use of these relationship will also be prepared for use in on-going training programs sponsored by the Wisconsin DOT.

Detailed Work Plan

Task 1: Literature Review

To effectively design the laboratory testing and data analysis for this project, the research team will undertake a literature review and a review of research in progress for the flow number test. The literature review will include:

1. A detailed review of Wisconsin DOT requirements for design and acceptance of HMA, and a review of acceptance requirements used by other agencies.
2. A critical review of the final report and database from WHRP Project Project 0092-04-07: *Testing Wisconsin Mixtures for the AASHTO 2002 Mechanistic Design Procedure*.
3. Compilation of testing conditions, volumetric properties, and flow number test data from other projects including: NCHRP Project 9-19, NCHRP Project 9-29, NCHRP Project 9-30A, WHRP Project 04-07, and the FHWA Mobile Asphalt Laboratory.
4. A review of publications addressing the effect of mixture composition of the rutting resistance of HMA.

The research team will also survey current flow number test research in progress to determine testing conditions for the flow number test that will likely be adopted nationally in the future. It is critical that appropriate testing conditions be used so that the database generated in this project can be expanded in the future to include the results from other projects. Dr. Bonaquist and Dr. Christensen will perform Task 1. The findings of this task will be included in the Interim Report that will be prepared in Task 3.

Task 2: Experimental Design

A detailed experimental design for the laboratory testing and analysis will be prepared in Task 2. This experimental design will include a number of compositional variations for each of the 12 mixtures that will be used in WHRP Project 0092-98-06. The WHRP Project 0092-98-06 mixtures will be selected considering: (1) design traffic level, (2) position in the pavement structure, (3) aggregate geology, and (4) availability of performance data. These mixtures will include the systematic variations in binder grade, design gyration level, and nominal maximum aggregate size that are incorporated in the Wisconsin mixture design requirements. Flow number data on each of these design mixtures will be collected in WHRP Project 00092-98-06.

In this project variations of each of these design mixtures will be tested. The compositional factors and factor levels to be included in this experiment will be guided by past research on the effect of mixture composition on rutting resistance, and the acceptance criteria used by the Wisconsin DOT and other agencies. It is anticipated that the following compositional factors will be included at one level above and one level below the design value:

- Specimen air void content (in-place air voids),
- Binder content,
- Percent passing –0.075 mm sieve

Based on the available budget, the number of flow number tests that can be included in the project is 196, which will limit the number of combinations that can be tested per design mixture to 8 when using two replicates per combination. A partial factorial experimental design, will therefore, be required. Development of the partial factorial experiment in light of statistical and engineering considerations will be the major activity completed in Task 2. Fortunately, some combinations, such as high binder content, high percent passing –0.075 mm and high in-place air voids can be eliminated because high binder and dust contents will not result in high in-place air voids.

Dr. Bonaquist and Dr. Christensen will jointly develop the experimental design for the project. The recommended experimental design will be included in the Interim Report in Task 3.

Task 3: Interim Report

In Task 3 the research team will compile and submit an Interim Report that presents the findings of the Literature Review, completed in Task 1 and the detailed Experimental Design developed in Task 2. The Interim Report will serve as a critical management tool for the Technical Oversight Committee ensuring that the design mixtures and proposed variations cover the range of mixtures produced in Wisconsin. Task 3 also includes a presentation by one of the Co-Principal Investigators to the Technical Oversight Committee to obtain approval to continue with laboratory testing and analysis. Dr. Bonaquist will be responsible for preparing the Interim Report with assistance from Dr. Christensen.

Task 4: Laboratory Testing

Task 4 includes five subtasks: (1) shipment of materials to AAT's laboratory in Sterling, VA; (2) fabrication of flow number test specimens; (3) flow number testing, and (4) entering the test results into the project database.

AAT proposes to coordinate the materials collection for this project with that required for WHRP Project 0092-08-06. The preliminary testing plan above includes 16 test specimens for each mixture. Additionally, four trial specimens and eight maximum specific gravity test are needed to adjust the compaction process to reach the target air void content and compute appropriate volumetric properties. Each flow number specimen requires approximately 6.5 kg of mix and the maximum specific gravity specimens require an additional 2 kg of mix. Thus, a total of approximately 150 kg of each mix will be required. Sufficient materials for 225 kg of each mixture will be shipped to AAT. This will provide extra material in case the sampled material does not match the gradation used in the mixture design.

Test specimen fabrication and testing will be performed by Senior Technicians at AAT under the direction of AAT's Laboratory Manager, Mr. Donald Jack. AAT's laboratory has prepared a large number of simple performance test specimens for several major research projects including, NCHRP Projects 9-19, 9-25, 9-29, 9-31, 9-34, and 9-36. Specimen fabrication will follow the procedures described in: *Proposed Standard Practice for Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor,* and flow number testing will be performed in accordance with: *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Simple Performance Test System.* Both of these procedures were developed by AAT during NCHRP Project 9-29. An Interlaken Simple Performance Test System will be used for the flow number testing.

The flow number test results and the corresponding specimen volumetric data will be entered into a database for subsequent analysis. Dr. Bonaquist will coordinate the laboratory testing effort. Both Dr. Bonaquist and Dr. Christensen will perform quality checks on the data as it is being added to the database.

Task 5: Data Analysis

In this task, the laboratory data collected in Task 4 will be analyzed to develop relationships between flow number and mixture composition. Regression will be the primary analysis tool used. The analysis of the laboratory data will be guided by analysis work previously completed by AAT in NCHRP Projects 9-25 and 9-31. The relationships between flow number and mixture composition developed from the laboratory data will be used to analyze current HMA mixture design and acceptance criteria used by the Wisconsin DOT. The objective of this analysis is to determine if adjustments to these criteria are warranted based on rutting resistance as measured by the flow number test. Task 5 will be completed by Dr. Christensen, with assistance from Dr, Bonaquist.

Task 6: Prepare Tutorial

In Task 6 a tutorial that demonstrates the use of the mixture composition – flow number models will be prepared. This tutorial is intended for use in training programs provided by the Wisconsin DOT for engineers and technicians involved in the design and acceptance of HMA.

Task 7: Compile Final Report

The final task, Task 7 includes the preparation and submission of the Final Report for the project, documenting all significant work completed during the project. The report will be prepared in accordance with the Wisconsin Highway Research Program requirements. A Draft

Final Report will be compiled by the research team and submitted to the Technical Oversight Committee for review and comment. The research team will address the comments, then compile and submit the required number of copies of the Final Report. An electronic database of the flow number test results will be included with the Final Report. Task 7 includes a closeout presentation by one of the Co-Principal Investigators to the Technical Oversight Committee. Dr. Bonaquist will be responsible for preparing the Final Report with assistance from Dr. Christensen.

Work Time Schedule

Figure 5 present the proposed time schedule. The first four months will be used to complete the literature review, develop the experimental plan, and prepare the Interim Report. A presentation of the experimental plan will be made to the Technical Oversight Committee in the 5th month of the project. Twelve months have been provided for the laboratory testing and four months for the data analysis. Two months are provided for preparation of the tutorial. The Draft Final Report will be submitted at the end of the 24th month of the project. Three months are provided for preparation and submission of the Revised Final Report. The close out presentation will be made in the 26th month of the project.

Task/Activity	**Contract Month**																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Task 1: Literature Review	X	X																									
Task 2: Experimental Design		X	X																								
Task 3: Interim Report				X																							
Task 4: Laboratory Testing						X	X	X	X	X	X	X	X	X	X	X	X										
Task 5: Data Analysis																		X	X	X	X						
Task 6: Prepare Tutorial																						X	X				
Task 7: Compile Final Report																								X	X	X	X
Presentations					X																					X	
Quarterly Reports				X				X				X				X				X				X			
Interim Report				X																							
Draft Final Report																								X			
Revised Final Report																											X

Figure 6. Project Schedule.

Reports

As part of the proposed work, AAT will submit six Quarterly Progress Reports, an Interim Report, a Draft Final Report, and a Revised Final Report. The Quarterly Progress Reports will be submitted no later than the 7th day following the end of in the quarter in the format required by the Wisconsin Highway Research Program. The Final Report will thoroughly document the project and will be prepared in accordance with the requirements of the Wisconsin Highway Research Program. Presentations will be made after submission of the Interim and Draft Final Reports.